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This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c).

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INVENTOR(S)

Given Name (first and middle [if any])	Family Name or Surname	Residence (City and either State or Foreign Country)
Thomas M.	**SULLIVAN**	**Indianapolis, Indiana**

☐ *Additional inventors are being named on the ____ separately numbered sheets attached hereto*

TITLE OF THE INVENTION (280 characters max)

APPARATUS AND METHOD OF CLEANSING CONTAMINATED AIR USING MICROWAVE RADIATION

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☒ Specification *Number of Pages* **26**
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☒ Drawing(s) *Number of Sheets* **3**
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Date **02/20/2004**

TYPED or PRINTED NAME **CHRISTOPHER W. BRODY**

REGISTRATION NO. *(if appropriate)* **33,613**

Docket Number: **71066-0011**

TELEPHONE **202-835-1111**

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APPARATUS AND METHOD OF CLEANSING CONTAMINATED AIR USING MICROWAVE RADIATION

Field of the Invention

This invention relates to conditioning air and to the cleaning of objects to remove objectionable components suspended in motile air or adhering to surfaces.

Background Art

Air quality is adversely affected by the presence of bacteria, viruses, fungal metabolites, spores, proteins, and an increasing myriad of volatile chemicals. Dust emanating from steel or cast iron abrading against steel can further degrade air quality as finely divided, surface-active particles are generated. Solid particles or microscopic biological contaminants can move through an area suspended in air or can be brought into a space on solid surfaces or among the recesses and interstices of garments or documents.

It is well known to one skilled in the art that the usefulness of cleanrooms used for medical purposes and for the manufacture of semiconductors is dependent upon air quality. Furthermore, confined spaces like railway cars, aircraft fuselages, and automobile interiors, may degrade in commercial viability as air quality degrades.

Underground railways generate dust from the constant abrasion of steel wheels against steel rails. Steel or iron dust is paramagnetic and may be reduced to particle sizes which are too small in size for all but HEPA filters, but too high in overall volume to be practically addressed by such high efficiency filters.

Variations of four basic methods have historically been used to control air quality. They include: 1) physical impaction on filters, 2) electrostatic precipitation of particles, 3) absorption of gases by solid sorbents, and 4) chemical reaction such as ozonation or ultraviolet light to convert particles or volatile chemicals to less objectionable products. Each method is deficient in some respect.

Physical impaction on filters is limited by the pore size of filters. HEPA filters have pore sizes down to 0.03 microns, but viruses can be as small as 0.003 microns, an order of magnitude smaller. Dust particles can also be smaller than the average pore size of the filters. In addition to limitations imposed by pore size, filters cause pressure to drop as flow is restricted and may not be able to handle very large amounts of very fine dust.

Electrotstatic precipitation of particles works by first charging particles then drawing them to oppositely charge collection plates. This method has difficulty coping with high

velocity air streams and has no capability to deal with volatile chemicals or difficult to charge particles.

Adsorption of cases by sorbents only works efficiently when the sorbent is specifically matched to the gases. Activated charcoal, a commonly used sorbent, requires that carbon particle characteristics be matched to the properties of the gases to be adsorbed. Adsorption also requires some measure of contact and can entail significant pressure drop.

Chemical reaction using ozone generated by electric discharge or by ultraviolet light is a very slow process due to the very low concentration of ozone in air and is unable to efficiently decontaminate high velocity air flow.

A variety of strategies have been developed to offset the shortcomings of the previously mentioned four methods. Usually they represent a combination of the methods.

U. S. Patent No. 5,938,823 describes an electrostatic precipitator method in which the collector plates are constructed of a semiconductive surface that absorbs microwaves so that it is heated and destroys biological contaminants. The inventor does not address the issue of biological contaminants or volatile chemicals in the airstream, which do not contact the collector plate. Though the inventor claims "a selectively operable microwave source," microwave frequencies are not mentioned. Indeed, the inventor describes an example of a collector plate achieving 500EF as evidence of the capacity of the system to

destroy biological contaminants thermally without recognizing that contaminants themselves may act like nodes or anti-nodes to attenuate microwaves. The inventor states that "According to the present invention a microwave absorbing collector plate of an electrostatic precipitator serves as a heat generator for heating captured particulate matter sufficiently to sterilize and/or disinfect microorganisms." Microwaves operate intermittently as needed to heat the collector plates to a desired temperature.

Biological contaminants may include spores having "carapace" outer structures. Spores with carapaces can be notoriously resistant to high temperature surfaces and have been shown to resist burning. Air purification technologies dependent upon momentary contact with hot "collector plates" offer no assurance of reliably decomposing spores.

Summary of the Invention

It is the object of the present invention to couple microwaves to contaminants so that resonance of the contaminants themselves converts the contaminants to relatively innocuous products without requiring physical contact or heating of the airstream as a whole. Only contaminants are heated, not the airstream as a whole because air does not resonate significantly when exposed to microwaves at the frequencies of interest.

Furthermore it is the object of the present invention to not impose a pressure drop on the air passing through the system.

Larger air volumes carrying more contaminants merely require more microwave power. With respect to the present invention, air velocity is not an issue except for the general function of the air conditioning system as a whole as would be known to one skilled in the art.

Contaminants lodged in and on solid objects including documents, garments, and microwave permeable structural materials are as readily resonated or attenuated as those suspended in flowing air. Documents or garments are placed in a microwave and exposed to microwaves at a sufficient power level and for a sufficient duration of time to decompose contaminants depending on the volume and composition of the contaminants. Garments comprising synthetic and natural fibers do not significantly couple with or attenuate microwaves at the frequencies claimed herein.

It is furthermore an object of the present invention to remove microscopic paramagnetic iron particles from an airstream by using an electromagnet without imposing a significant pressure drop on the airstream. Magnetic flux is shielded so that it is not problematic to nearby people or systems.

In satisfaction of the foregoing objects and advantages, and in one mode, the invention includes an apparatus for cleansing air, comprising a source of microwave radiation that couples with or attenuates contaminants or in air to cause destructively resonant vibrations and to cause destructive dipole polarization,

electrical coupling, and/or interfacial polarization of the contaminants or impurities. A tube or other containment structure is provided through which air passes as it is exposed to microwave radiation. The containment structure is made from materials, which are invisible or nearly invisible to the microwave frequencies absorbed by contaminants. An air permeable material covers each end of the tube. The containment structure can be made from materials selected from the group consisting of alumina, Pyrex® glass, quartz, sapphire, silicon nitride, or polymer. The surface of the containment structure in contact with the contaminated gas preferably comprises yttrium oxide, rare earth oxides, or titanium oxide, as these materials act as catalysts and enhance the destruction of the contaminants/impurities.

A preferred source of microwave radiation uses a microwave radiation frequency between 433 and 435 MHz, 902 MHz and 928 MHz or 2.4 and 2.5 GHz.

The air permeable material can be one of a screen material, perforated metal, or wire mesh. The air permeable material has openings sufficiently small enough to prevent radiation leakage. The air permeable material can also have a surface comprised of a metal from Group VIII of the periodic table to act as a catalyst, preferably palladium or platinum.

The impurities/contaminants can be virtually any type, but preferred impurities or contaminants comprise bacteria, viruses,

fungal metabolites, spores, chemicals and proteins. More preferred agents to be treated include spores as endospore-forming bacillus, bacteria as Clostridium botulinum, protein as ricin, prion-containing proteins, and volatile chemicals such as organofluorophosphonate acid esters, organothiophosphonate acid esters, 1,1'-Thiobis[2-cloroethane], 2-Cloro-N-(2-cloroethyl)--methylethanamine, and Dichloro(2-chlorovinyl)arsine.

The invention also treats contaminants/impurities found on solid objects. In this mode, the apparatus for cleansing solid objects comprise a housing including a source of microwave radiation that couples with or attenuates contaminants or impurities on the surface of, within the recesses or interstices of, or surrounded by solid objects, which are microwave permeable to cause destructively resonant vibration. The solid objects are contained in a microwave reflective enclosure that has a passageway to atmosphere. The passageway is covered by an air permeable material that has an opening sized to prevent escape of microwaves from the enclosure. The passageway allows for thermal expansion within the microwave-radiated atmosphere. A supportive structure is also provided within the housing to support the solid object during treatment, the supportive structure being invisible or nearly invisible to microwave radiation. As with the continuous-type air treatment apparatus, preferred frequencies for batch treating of solid objects are between 433 and 435 MHz, 902 MHz and 928 MHz and between 2.4 and 2.5 GHz.

The solid objects can be virtually any solid object, and preferred classes of objects include paper or paper-containing objects, garments, fabrics, wood, concrete, bricks, concrete blocks, earth, stone, wood, and foods such as meat.

The supportive structure can be a tray or pan and be made from one of alumina, Pyrex® glass, quartz, sapphire, silicon nitride, or polymer.

The gas or air permeable materials described above as well as the catalyst can also be utilized in the batch treatment process. The solid objects can also be treated in a continuous manner using material handling equipment, and the necessary sealing at entrance and exits to assure that microwave radiation does not escape.

The invention also includes a method of treating air containing paramagnetic dust particles, as is commonly found in underground railway sites. In this mode, the method comprises providing a stream of air that contains the paramagnetic dust particles. An electromagnet is provided and positioned so that the stream of air passes through the electromagnetic flux created by the electromagnet to remove the dust particles from the air stream. Magnetic shielding materials can be used to shield the electromagnet so that only the stream of air is subjected to the electromagnetic flux. This embodiment can be used in a stand alone manner, coupled with the microwave treatment apparatus, or some other conventional air conditioning systems.

Preferably, the air being treated is that found in underground railways since these areas contain the paramagnetic dust particles from various metals contacting other metals. The shielding can also be used to protect passengers in the railway.

Brief Description of the Drawings

Reference is now made to the drawings of the invention wherein:

Figure 1 shows a schematic arrangement of one embodiment of the invention;

Figure 2 shows a schematic arrangement of another embodiment of the invention; and

Figure 3 shows an exemplary arrangement of a yet another embodiment of the present invention.

Description of the Preferred Embodiments

The present invention offers a significantly improved way to cleanse air that contains contaminants. These contaminants can take on any form in terms of bacteria, viruses, and the like. The invention uses microwave energy to effectively destroy the contaminants via resonance. The invention can treat contaminated air in a continuous fashion whereby air passing through a tube that is essentially transparent to microwave radiation is subjected to the radiation. Contaminants entering the tube are rendered harmless by the radiation. Since the contaminants do

not constitute a large percentage of the air volume, collection treatment downstream of the tube is generally unnecessary.

The invention uses the same principle to effectively destroy contaminants on solid objects by placing the objects in a housing or chamber and subjecting the objects to the same microwave radiation.

A preferred embodiment of the present invention comprises using a 433-435 MHz, 902-928 MHz 902-928 MHz or 2.4-2.5 GHz frequency microwave source. The microwave source can be any conventional type, e.g., a magnetron, and can be so configured as to expose the contents of a round tube or other containment structure made from materials, which are invisible or nearly invisible to the previously mentioned microwaves frequencies. The containment structure is located in a container that reflects the microwaves. Screens, perforated plates, or the like which are permeable to air cover each end of the round tube to enable air to pass into the tube from one end and exit from the other without microwave leakage. In this manner, air laden with contaminants like bacteria, viruses, and the like flows through a screen and into a tube where microwaves couple with the contaminants and water in the air and convert the mixture to harmless, unoffensive byproducts. One skilled in the art will recognize that the residence time of contaminant laden air in the tube is a function of the contaminant species in relation to coupling or attenuating efficiency at a particular frequency and

the power level of the microwave source in the context of arbitrarily selected standards of quality for the air after microwave treatment. In addition, the manner in which the contaminated gas is supplied to the containment structure can be any type so long as the gas is directed through the containment structure for treatment. Likewise, collection of the exiting and treated gas can be done in any fashion, or the gas can be merely exhausted to atmosphere.

The containment structure can be made from a multitude of materials, which are penetrated to great depth by microwaves and well known to one skilled in the art. A tube, more preferably a round tube is preferred as the containment structure, but non-round cross section shapes could be used. Preferably, the containment structure is made from high purity aluminum oxide, Pyrex glass, quartz, sapphire, silicon nitride, or polymer.

Because air exposed to microwaves may be converted to ozone, the outlet screen can be made from or covered with a metal catalyst metal taken from Group VIII of the Periodic Table, but preferably an eutectic mixture composed primarily of palladium, to facilitate half reactions in the formation of reaction co-products which are not objectionable.

Figure 1 depicts an apparatus 10 of the present invention in which microwaves from a microwave emitter 1 are reflected and redirected continuously by a rotating stirrer 3 into an outer box 5 to contain the microwaves. Microwaves are continuously

reflected in an inner box 6 and pass through a gas containing tube 7 contained therein. The microwaves are absorbed by contaminants in air 8 passing through the tube 7. Air entering the gas containing tube 7 within the microwave atmosphere passes through finely divided metal surfaced screen 11 and out of the gas containing tube 7 through another finely divided metal surfaced screen 11. The screen openings are sized to prevent escape of microwaves from the tube 7. Decontaminated air 13 exits the screen 11, and can be discharged to atmosphere.

Another embodiment of the present invention involves purifying garments or documents or other solid objects that may contain contaminants. Again, a 433 to 435 MHz, 902-928 MHz or 2.4-2.5 GHz frequency microwave source is so configured that microwaves emanating from this microwave source pass through garments or documents, which may have adsorbed bacteria, viruses, fungal metabolites, spores, proteins, or volatile chemicals, that are supported on a tray or pan made from a material, like the previously mentioned tube, which is penetrated to great depth by the microwave frequencies of interest and is essentially invisible to microwaves. Water and hydrogen may be continuously added to facilitate destruction of the contaminants. The amount of water, whether it be in the form of steam, water, or water vapor and/or hydrogen, if used, should be at least on a 1:1 molar ratio basis with any amide or imide radical group found in the contaminant/impurity. The hydrogen should be no greater than 4%

by volume of the atmosphere in the treatment space. The hydrogen and water can be introduced together or separately, and done in any conventional fashion.

A structure such as a tray, pan or the like is configured to support the garments, paper products such as envelopes, documents or other objects and is located in a microwave reflective box which is itself located within an outer box that contains all microwaves and prevents leakage to the atmosphere. Other examples of objects that can be treated include concrete, bricks, concrete blocks, earth, stone, wood, and food such as meat. It will be recognized that documents, garments, woven fabrics, and other solid objects may be continuously carried through the chamber by systems like conveyors which are well known to one skilled in the art. These material handling systems would also include the necessary sealing features to assure that microwave radiation does not escape with the continuous entry and exit of solid objects.

Figure 2 shows an exemplary microwave system 20 for decontaminating solid objects. The system includes a blower fan 21 that directs cooling air over a microwave source 23, and stirrer 25, all positioned in an outer box 27. Microwaves are continuously reflected by the stirrer 21 into a microwave reflecting metal case 29 which may contain solid objects 31. Microwaves penetrate and decontaminate the solid objects 31. Air and gases exit the microwave atmosphere in the metal box through

a finely divided metal screen 33. If required, sources of hydrogen and water are shown as 35 and 37. The microwave reflective box 29 may include a supportive structure such as a tray or pan 32 to support the solid objects. The supportive structure should be invisible or nearly invisible to the microwaves so that the objects are maximally exposed to the radiation during the treatment cycle.

Examples of impurities/contaminants found in air or in or on objects and which can be treated by the invention include bacteria, viruses, fungal metabolites, spores, volatile chemicals, and proteins. Specific examples in include ricin, proteins with prion, bacteria such as Clostridium botulinum, spores such as endospore-forming bacillus. Volatile chemicals can include organofluorophosphonate acid esters, organothiophosphonate acid esters, 1,1'-Thiobis[2-cloroethane], 2-Cloro-N-(2-cloroethyl)--methylethanamine, and Dichloro(2-chlorovinyl)arsine.

It is believed that microwaving these contaminants causes destructive dipole polarization, electrical coupling, and/or interfacial polarization. The contaminants could be found on the objects or in interstices or recesses thereof or are airborne.

Another aspect of the invention involves cleansing air that contains amounts of paramagnetic iron dust particles. In this embodiment of the present invention, a microwave air conditioner may be used upstream of a ventilation system by an

electromagnetic plate that attracts and holds iron particles suspended in ventilation air until they are released by terminating electric power to the electromagnet. In an alternative use, the microwave air conditioner can be used on its own to treat the dust-laden air.

The air conditioner uses an electromagnet that is positioned or configured such that air intended to be treated is passed by the electromagnet. In this way, the electromagnetic flux attracts the paramagnetic iron dust particles in the air, thus leaving the air free of these materials. The particles can then be collected at the appropriate time by depowering the electromagnet. Figure 3 shows an exemplary apparatus 40, wherein the contaminated air 41 enters an elbow 43 at entrance 44. An electromagnet 45 is positioned to collect the paramagnetic dust so that dust-free air exits the system at 45. It is preferred to position the electromagnet 43 above the vertical leg 47 of the elbow 40 so that once it is depowered, the collected dust falls vertically and can be collected at or below the entrance 44 with any conventional collecting means such as a tray, vacuum or the like. This embodiment can be linked to the apparatus 10 shown in Figure 1, if so desired. Alternatively, the system can be used as a precursor to any other air treatment system, or used on its own.

The electromagnet preferably using magnetic shielding materials, which are represented by the hatching 49 so that the

flux is concentrated on the air stream being treated, and other nearby systems, devices, or people are protected from the flux.

The invention also entails methods of destroying the contaminants/impurities using the apparatus described above. Referring to the Figure 1 embodiment, the contaminated air is provided and passed through the containment structure so that it can be treated by the microwave radiation to cause destructive dipole polarization, electrical coupling, and/or interfacial polarization of the contaminants or impurities. The decontaminated air then exits the containment structure. Similarly, the solid objects believed to be contaminated are placed on the support structure and subjected to the microwave radiation, in the presence of sufficient moisture, or added moisture if necessary for contaminant destruction. Hydrogen as a catalyst can be added to the atmosphere enveloping the solid objects. The water and hydrogen amounts should be at least a 1:1 molar ratio based on the presence of amide or imide radical groups in the contaminants/impurities being destroyed. If there is sufficient humidity in the air, addition of water, water vapor or steam may not be required. Likewise, the use of hydrogen is optional, although its presence increases the rate of destruction significantly, e.g., up to four times as fast. The source of water, water vapor and steam, as well as the hydrogen can be from any conventional source, and these materials are desirable for

their ability to permeate a number of different materials, e.g., paper.

It should also be understood that the air permeable material can be of any form that allows the contaminated and decontaminated air to pass through, and can contain or have as a part thereof, a catalytic structure similar to that described above. Moreover, the catalytic structure can be located at both the entry and exits of the containment structure of the inventive apparatus.

As such, an invention has been disclosed in terms of preferred embodiments thereof, which fulfills each and every one of the objects of the present invention as set forth above and provides a new and improved system for conditioning air.

Of course, various changes, modifications and alterations from the teachings of the present invention may be contemplated by those skilled in the art without departing from the intended spirit and scope thereof. It is intended that the present invention only be limited by the terms of the appended claims.

Abstract

An air conditioning system uses microwave radiation to effectively destroy airborne contaminants. In one mode, air is passed through a microwave-transparent tube and is subjected to microwave radiation to cause destructive dipole polarization, electrical coupling, and/or interfacial polarization of the contaminants or impurities found in the air. In another mode, solid objects are decontaminated by subjecting the objects to microwave radiation. Paramagnetic dust particles in the air, especially underground railway air, can also be removed using an electromagnet.

Figure 1

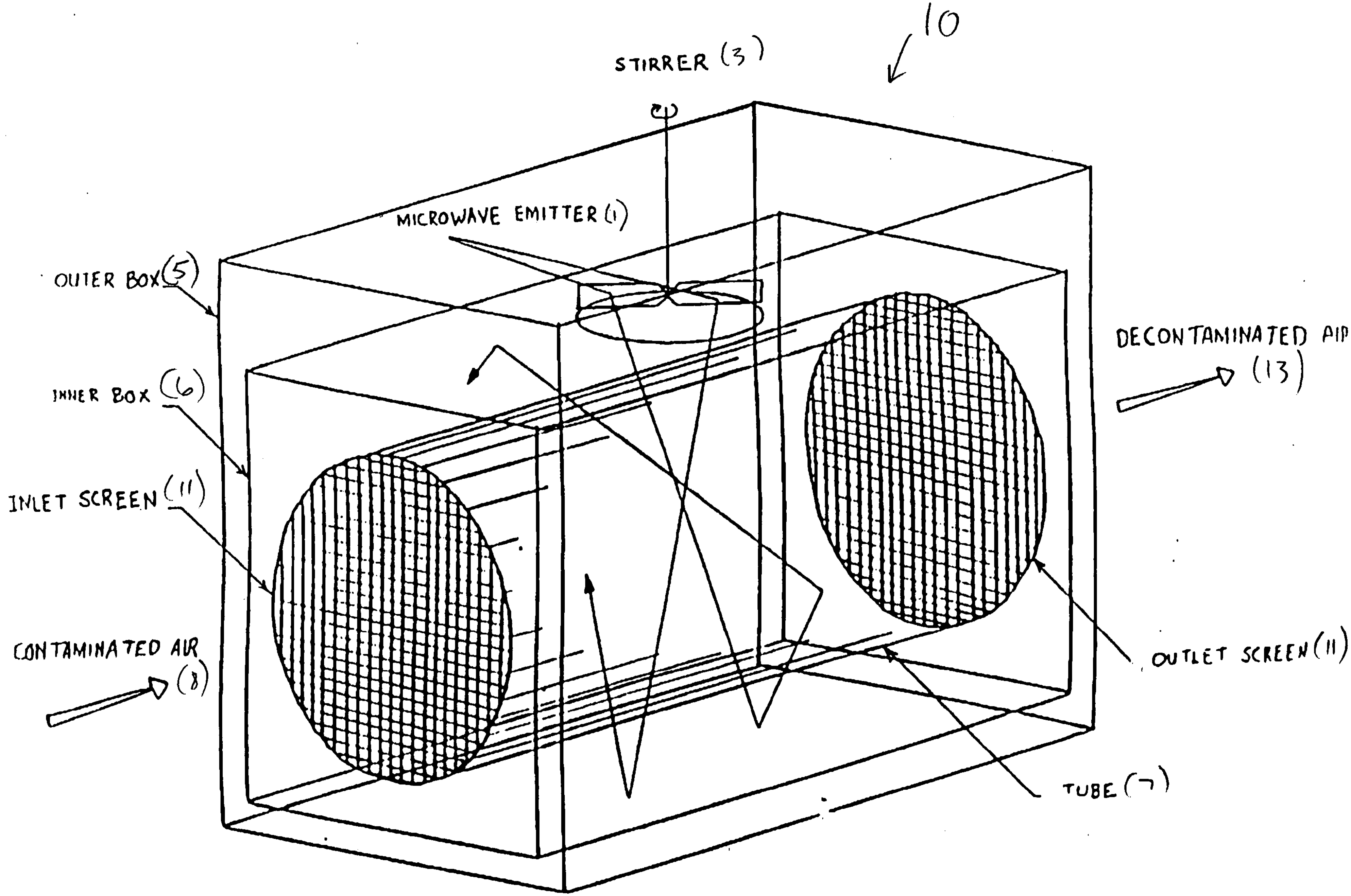
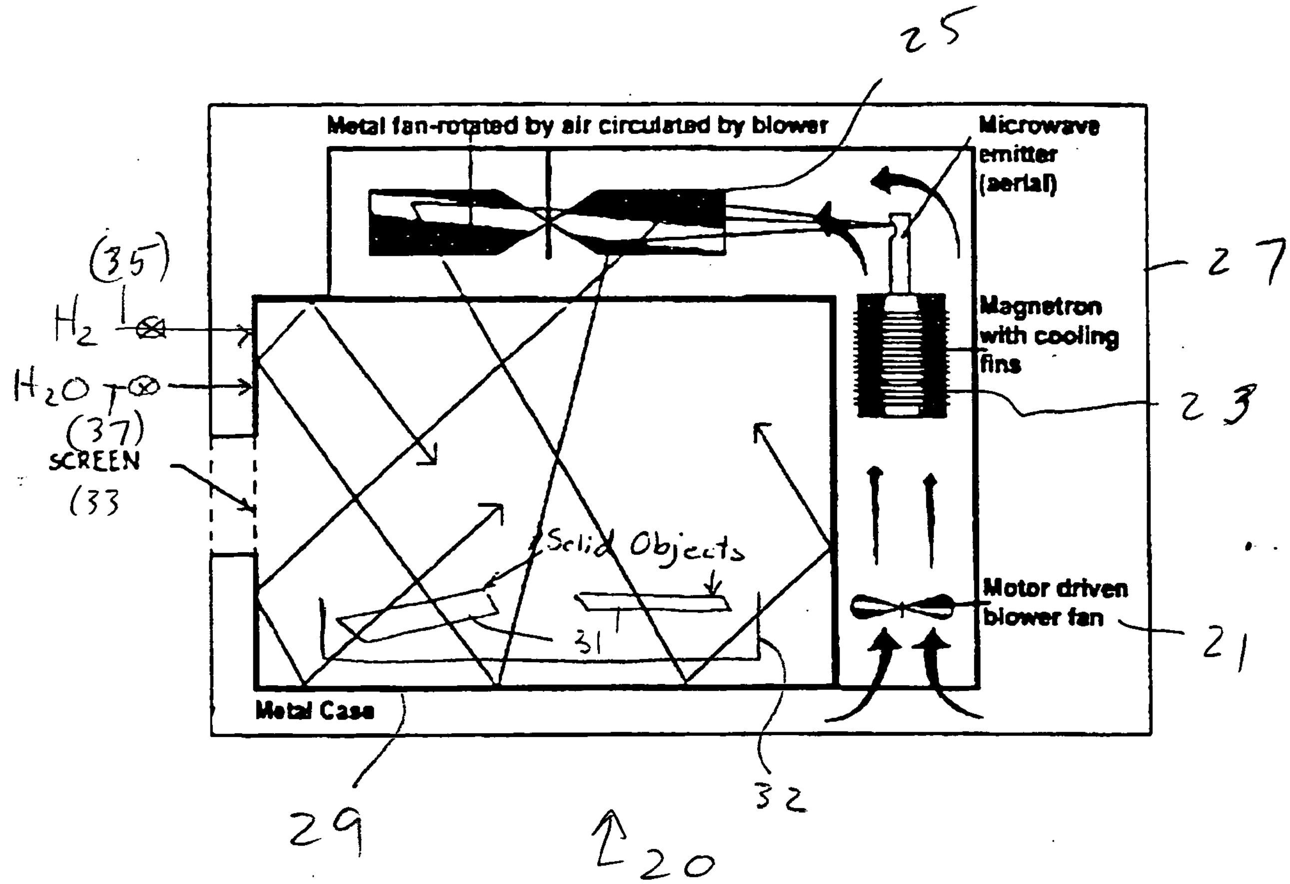
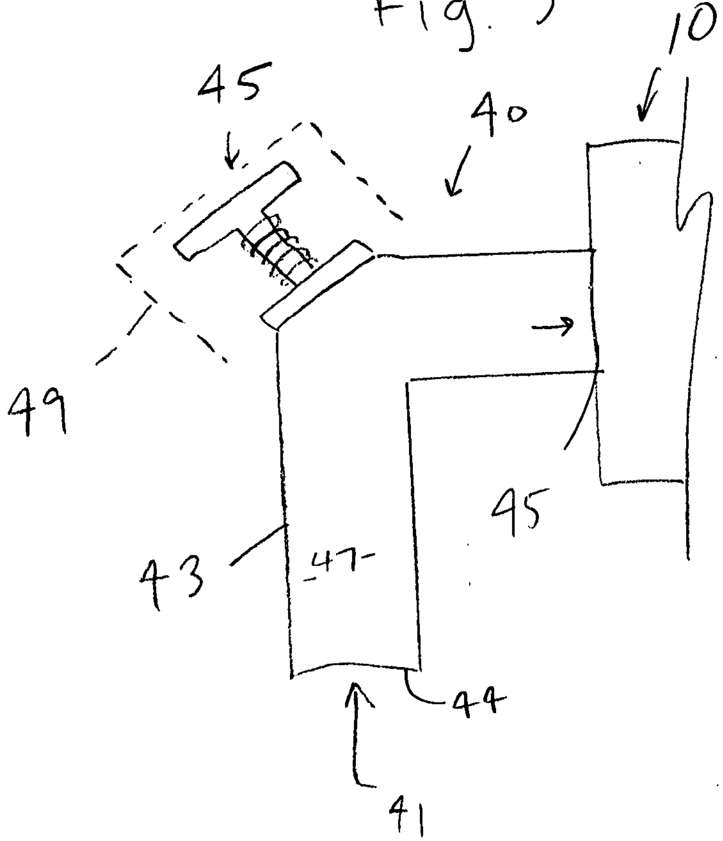

10
STIRRER (3)
MICROWAVE EMITTER (1)
OUTER BOX (5)
INNER BOX (6)
INLET SCREEN (11)
CONTAMINATED AIR (8)
DECONTAMINATED AIR (13)
OUTLET SCREEN (11)
TUBE (7)

Figure 2



25
Metal fan-rotated by air circulated by blower
Microwave emitter (aerial)
27
(35)
H_2
H_2O
(37)
SCREEN
(33
Magnetron with cooling fins
23
Solid Objects
31
Motor driven blower fan
21
Metal Case
29
32
20

Fig. 3



What Is Claimed Is:

1. An apparatus for cleansing air, comprising:

a) a source of microwave radiation that couples with or attenuates contaminants or impurities in air to cause destructively dipolar polarization, electrical coupling, and/or interfacial polarization of the contaminants:

b) a containment structure having opposing ends and which through gas containing the contaminants or impurities passes as it is exposed to microwave radiation, the containment structure being made from materials which are invisible or nearly invisible to the microwave frequencies;

c) a gas permeable material covering each end of the containment structure, the gas permeable material having openings of a size that prevent microwaves to escape, and being covered with a metal catalyst taken from the Group VIII of the periodic table.

2. The apparatus of claim 1, wherein the source of microwave radiation uses a microwave radiation frequency between 433 and 435 MHz, 902 MHz and 928 MHz, or 2.4 and 2.5 GHz.

3. The apparatus of claim 1, wherein the containment structure is made from materials selected from the group

consisting of alumina, Pyrex® glass, quartz, sapphire, silicon nitride, or polymer.

4. The apparatus of claim 1, wherein the air permeable material is one of a screen material, perforated metal, or wire mesh.

5. The apparatus of claim 1, wherein the Group VIII metal is one of palladium or platinum or an alloy thereof.

6. The apparatus of claim 1, wherein a surface of the containment structure in contact with contaminated air includes one of yttrium oxide, a rare earth oxide, or titanium oxide.

7. The apparatus of claim 1, wherein the containment structure is a tube.

8. An apparatus for cleansing solid objects, comprising:

a) a housing including a source of microwaves that deeply penetrates and is directly absorbed by contaminants or impurities on the surface of, within the recesses or interstices of, or surrounded by solid objects which are microwave permeable to cause destructive dipole polarization, electrical coupling, and/or interfacial polarization of the contaminants or impurities,

b) a microwave-reflective enclosure for containing the solid object, and optionally a supportive structure within the housing

and sized to hold the solid object, the supportive structure made from materials which are invisible or nearly invisible to the microwave frequencies; and

c) a passageway in the microwave reflective enclosure and a air permeable material covering the passageway, the air permeable material having openings too closely spaced to permit microwaves to escape, the passageway allowing thermal expansion within the microwave radiated atmosphere;

d) optionally a source of water, water vapor or steam if the atmosphere in the enclosure does not have sufficient quantity of water; and

d) optionally a source of hydrogen as a catalyst for said destruction of the contaminants.

9. The apparatus of claim 8, wherein the source of microwave radiation uses a microwave radiation frequency between 433 and 435 MHz, 902 MHz and 928 MHz, or 2.4 and 2.5 GHz.

10. The apparatus of claim 8, wherein the hydrogen is up to 4% of the atmosphere within the housing.

11. The apparatus of claim 8, wherein the supportive structure is a tray or pan to hold one or more of the solid objects.

12. The apparatus of claim 11, wherein the supportive structure is made from one of alumina, Pyrex® glass, quartz, sapphire, silicon nitride, or polymer.

13. The apparatus of claim 8, wherein the air permeable material is one of a screen material, perforated metal, or wire mesh.

14. The apparatus of claim 8, further comprising the sources of hydrogen and water, water vapor, and/or steam.

15. The apparatus of claim 8, wherein the air permeable material has a surface comprised of a metal from Group VIII of the periodic table to act as a catalyst.

16. The apparatus of claim 15, wherein the metal is palladium or platinum or an alloy thereof.

17. A method of cleansing contaminated air containing paramagnetic dust particles comprising:

a) providing a stream of air that contains the paramagnetic dust particles;

b) providing an electromagnet;

c) passing the stream of air through an electromagnetic flux generated by the electromagnet to remove the paramagnetic dust particles from the stream; and

d) optionally depowering the electromagnet to release the removed paramagnetic dust for collection.

18. The method of claim 17, further comprising shielding the electromagnet using magnetic shielding materials so that only the stream of air is subjected to the electromagnetic flux.

19. The method of claim 17, wherein the stream of air comes from an underground railway.

20. The method of claim 18, wherein the stream of air comes from an underground railway.

21. The method of claim 18, wherein the magnetic shielding materials are used to protect rail passengers in the underground railway.

22. A method of destroying contaminants in air comprising:

a) providing the apparatus of claim 1 and a source of contaminated or impurity laden air; and

b) passing contaminant-containing air through the apparatus; and

c) subjecting the air to microwave radiation as produced by said apparatus; and

d) optionally exposing the air to a catalyst such as yttrium oxide, a rare earth oxide, or titanium oxide during the subjecting step.

23. The method of claim 22, wherein the impurities or contaminants comprise bacteria, viruses, fungal metabolites, spores, chemicals, and proteins.

24. The method of claim 23, wherein one or more of the following apply:

the spores are formed by endospore forming bacillus, the bacteria is Clostridium botulinum, the protein is ricin, the proteins include prions, and the volatile chemicals comprise organofluorophosphonate acid esters, organothiophosphonate acid esters, 1,1'-Thiobis[2-cloroethane], 2-Cloro-N-(2-cloroethyl)--methylethanamine, and Dichloro(2-chlorovinyl)arsine.

25. A method of destroying contaminants/impurities on solid object comprising:

a) providing the apparatus of claim 8 and one or more contaminated or impurity laden solid objects;

b) placing the one or more solid objects in the supportive structure;

c) subjecting the one or more solid objects to microwave radiation to destroy contaminants/impurities associated with the one or more solid objects, including the optional introduction of water, water vapor, or steam, and hydrogen into the supportive structure to enhance the destruction process.

26. The method of claim 25, wherein the impurities or contaminants comprise bacteria, viruses, fungal metabolites, spores, chemicals, and proteins.

27. The method of claim 26, wherein one or more of the following apply:

the spores are formed by endospore forming bacillus, the bacteria is Clostridium botulinum, the protein is ricin, the proteins include prions, and the volatile chemicals comprise organofluorophosphonate acid esters, organothiophosphonate acid esters, 1,1'-Thiobis[2-cloroethane], 2-Cloro-N-(2-cloroethyl)--methylethanamine, and Dichloro(2-chlorovinyl)arsine.

28. The method of claim 25, wherein a molar ratio of water and/or hydrogen to an amide or imide radical group found in the contaminant/impurity is at least one to one.

29. The method of claim 28, wherein hydrogen in the atmosphere comprises up to 4% by volume.

30. The method of claim 25, wherein the solid objects further comprise paper or paper-containing objects, garments, fabrics, wood, concrete, bricks, concrete blocks, earth, stone, wood, and foods such as meat.

31. An apparatus for treating paramagnetic dust, particularly in underground railways comprising:

a) a source of paramagnetic dust-containing air;

b) ductwork having an entry for receiving the paramagnetic dust-containing air and an exit for discharging ess entially dust free air;

c) an electromagnet positioned adjacent the ductwork and between the entry and exit for collecting the paramagnetic dust when powered.

32. The apparatus of claim 31, wherein the ductwork is in the shape of an elbow with one generally vertical leg, the generally vertical leg containing the entry, the electromagnet positioned at the direction change of the elbow, so that depowering of the electromagnet releases collected paramagnetic dust for collection at the entry of the elbow.